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GB 2233570 A EP 0761259 A1 US 5792028 A
US 5514053 A US 5044355 A US 3941377 A

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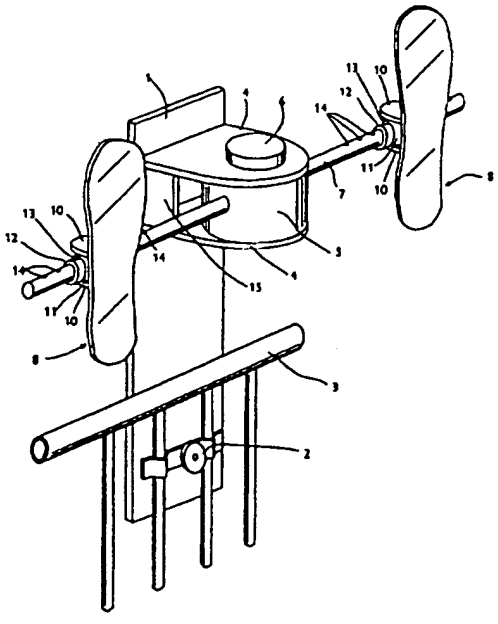
(54) Abstract Title
Rehabilitative exercise device for beds

(57) A rehabilitative exercise device has two foot supports 8 connected together, which are alternately reciprocatable back and forth in a generally horizontal plane, and pivotable about a horizontal axis perpendicular to the direction of reciprocation. The foot supports 8 may be mounted on a pivotable shaft 7 and be pivotable about a vertical axis relative to the shaft 7. The foot supports may extend from a casing, and be connected to endless belts (figs 7, 8). The device can be clamped 2 to the end of a bed 3. Shaft 7 and foot support 8 rotation may be limited. Variable clamping resistance can prevent shaft 7 pivoting (fig 2). Leg bending exercises can thus be conducted by pushing a foot forward against the resistance of the other foot or of the device, and ankles and calf muscles exercised by swivelling of the foot supports 8 about the horizontal axis. Such swivelling may also reposition the supports 8 on the shaft 7. Supports 8 may be attached by connecting rods and having rollers running along parallel tracks in a body (fig 6). Deep venous thrombosis can be prevented after hip or knee surgery.



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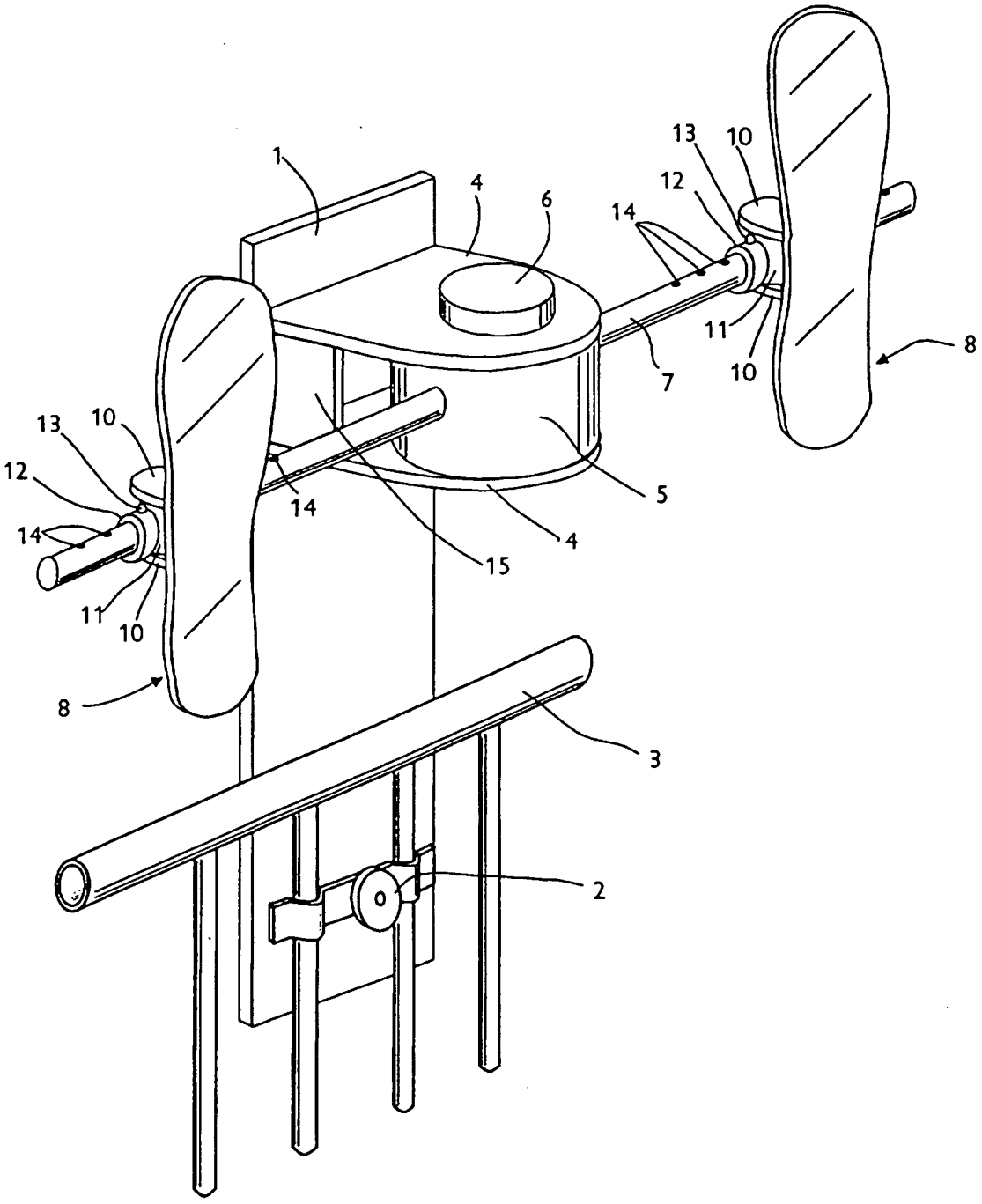
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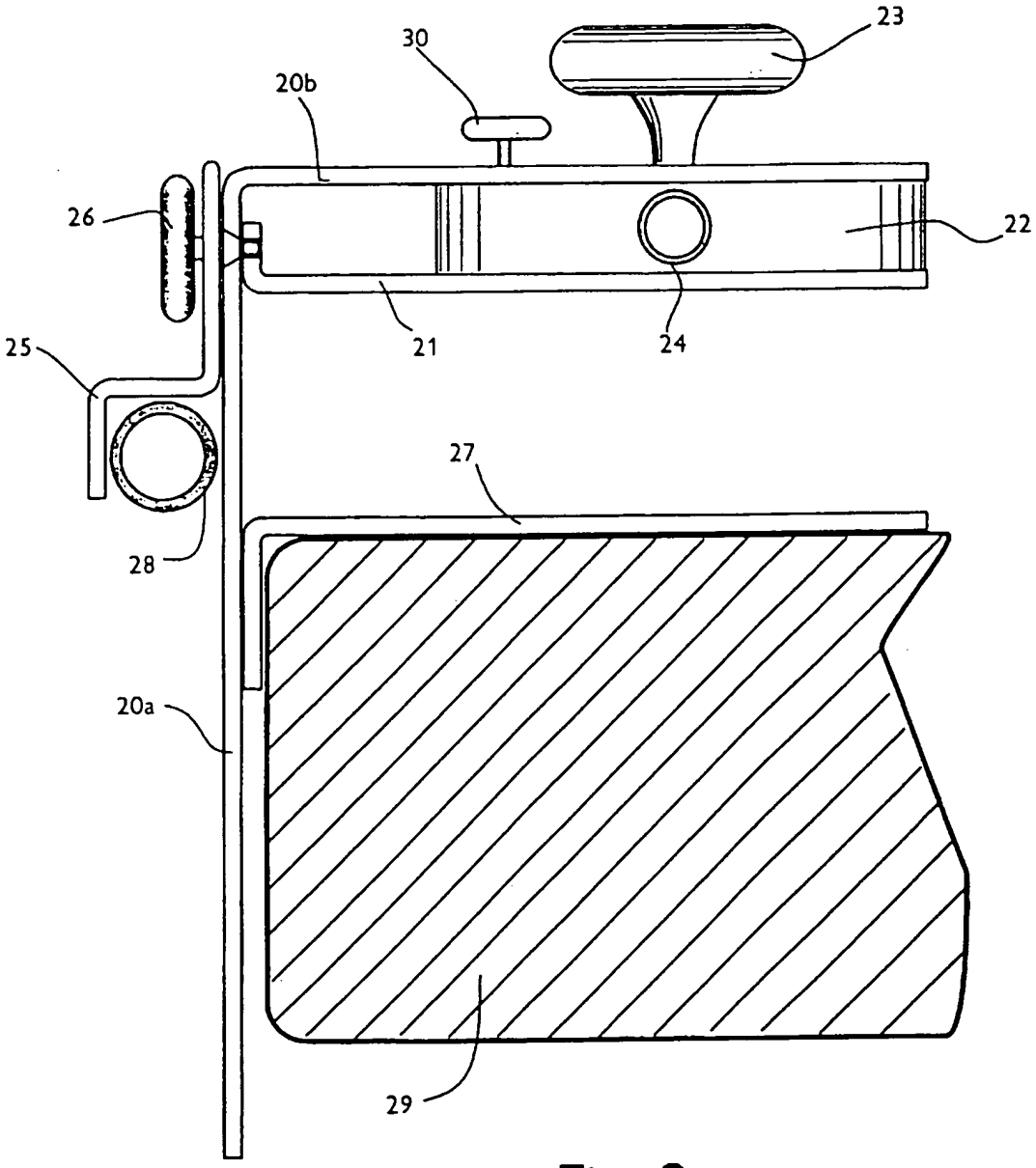

Fig 2

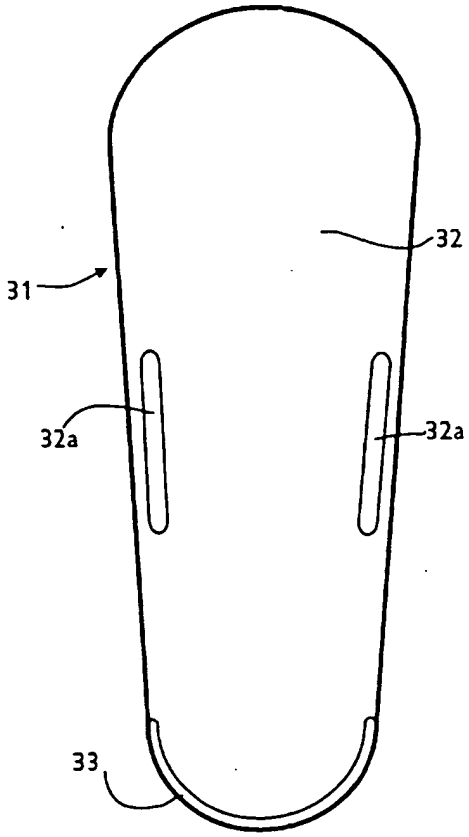

Fig 3

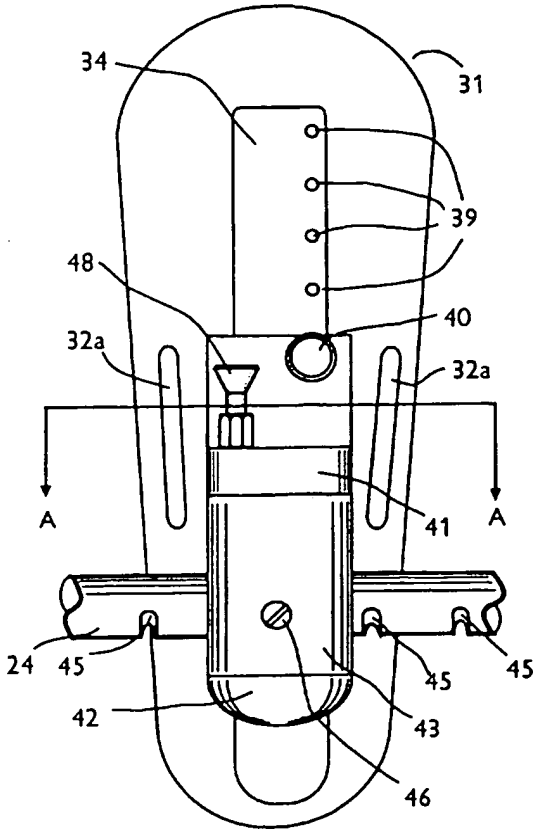

Fig 4

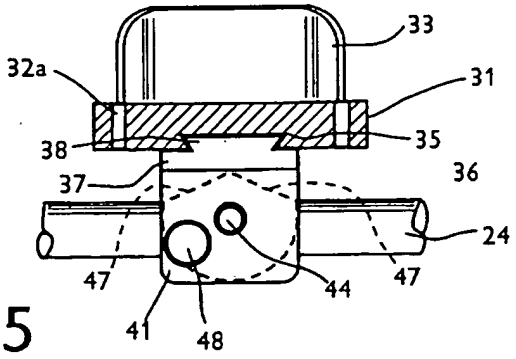

Fig 5

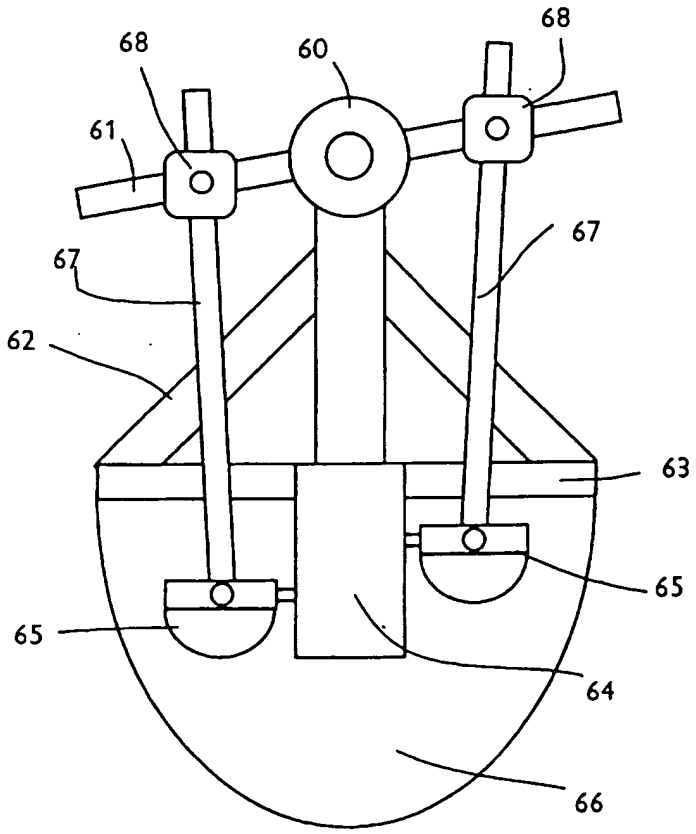

Fig 6

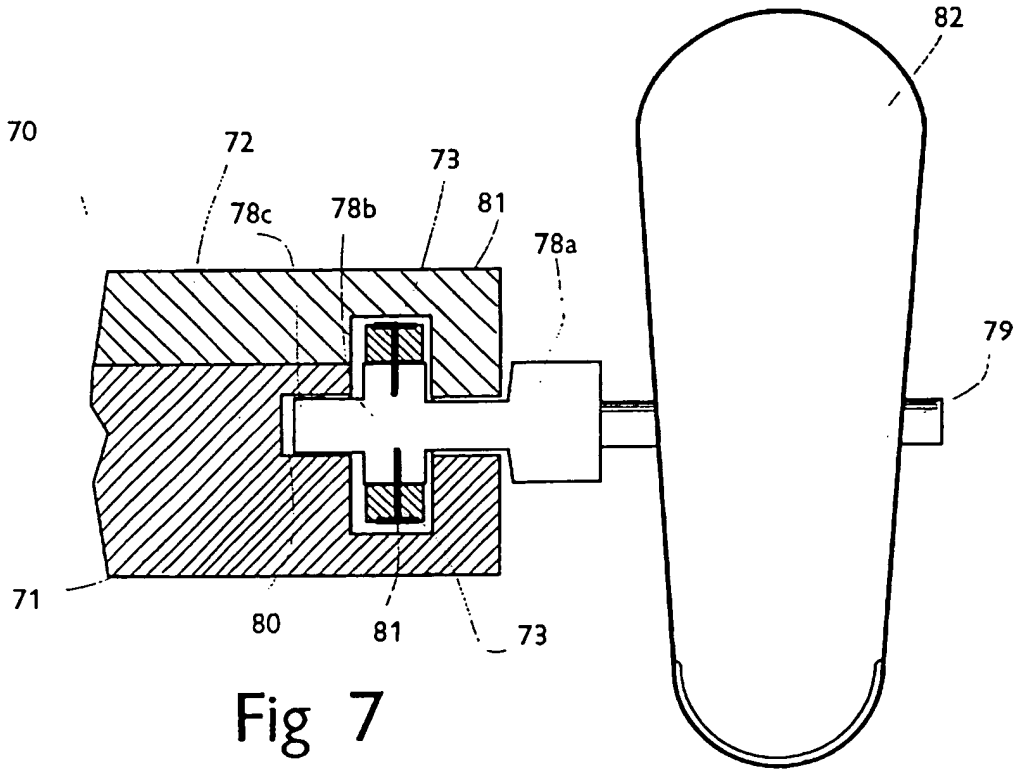

Fig 7

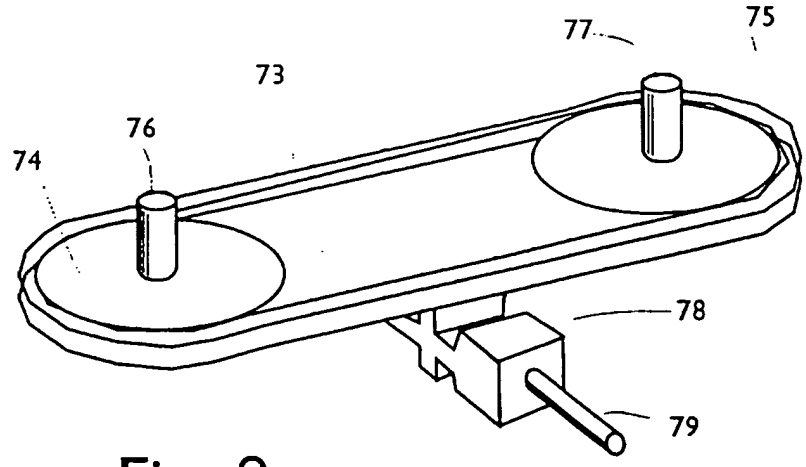

Fig 8

REHABILITATIVE EXERCISE DEVICE

Field of the Invention

This invention relates to a rehabilitative exercise device for use, for example, in assisting in the recovery of lower limb function in the post-operative period after hip or knee surgery, including joint replacement.

Background to the Invention

It is generally recognised as important for hip and knee surgery patients, especially those who have undergone replacement of components of the hip or knee joints, to exercise the joints as soon as possible after surgery, to ensure that the joint is as mobile as possible in the long term. Exercise also helps in promoting functional healing of the joint structures.

Patients are encouraged to get back on their feet as soon as possible after surgery, to reduce the risk of deep venous thrombosis. To assist in preparing for this early mobilisation, exercise devices are used which assist flexion of the joint A typical device comprises an articulated support to which the leg is attached, and which is then bent to cause flexion of the knee joint. Such machines are relatively complex and costly, which limits their use to short sessions for each patient, but the operation of the device by a third party can cause resistance to such exercise by the patient, as flexion is often painful, and is of the passive rather than active form. The exercise regime resulting from the use of such machines is referred to as Continuous Passive Movement, or "CPM".

There is a need for a simple, user friendly and affordable device which assists the patient to perform exercises on a "little but often" basis controlled by the patient rather than by a therapist. The Controlled Active Movement or "CAM" allowed by such a device will theoretically improve the "muscle pump" in the lower limb to reduce swelling and increase venous flow. The "muscle pump" is the effect by which venous blood flow in the leg is increased by flexion of, for example, the calf muscles, and is thought to be an important factor in reducing deep venous thrombosis (see, for example, *Westrich et al, "Venous Haemodynamics after total knee arthroplasty: evaluation of active dorsal to plantar flexion and several mechanical compression devices.", J Bone Joint Surg Br, 1998 Nov 80(6): 1057-66).*

Summary of the Invention

According to the invention there is provided a rehabilitative exercise device comprising a support means mounting two foot supports connected together so as to be alternately reciprocable relative to the support means in a single, generally horizontal, plane, each foot support being freely and independently pivotable about a respective horizontal axis extending generally transversely of the direction of reciprocation.

The support means preferably includes an endless drive member passing around a spaced pair of horizontal wheels, the foot supports being carried on respective horizontal bars attached to opposed runs of the endless drive member. A second endless drive member preferably passes around a second pair of horizontal wheels spaced vertically from and coaxial with the first pair, the second drive member also being attached to the horizontal bars. The or each endless drive member may be a chain and the wheels are then suitably sprocket wheels. Alternatively, the drive member may be a toothed drive belt, for example of the general type used as motor vehicle engine cam belts, with the wheels being preferably toothed correspondingly.

The rehabilitative exercise device may comprise a support means mounting a generally horizontal member pivoted generally centrally thereof about a substantially vertical axis, and two foot supports coupled to the shaft, one each side of the axis, so as to be alternately reciprocable in a generally horizontal plane, each foot support being pivotable about a substantially vertical axis.

The support means may be attached to the end of the patient's bed so that exercise can be carried out while the patient is lying down in bed. For example, a removable clamp may permit temporary clamping of the device to the bed end. The device permits the patient to carry out a simple leg bending and straightening exercise, by pushing one foot against the resistance afforded by the other, or by the device itself, via the foot supports, to a degree chosen by the patient.

Means may be provided to control the resistance to rotation of the shaft about the vertical axis. For example, a variable friction arrangement may be used to increase the resistance in stages as the patient's muscles recover and strengthen. This may involve a simple screw adjustment to permit incremental increases in the resistance to be made throughout the patient's rehabilitation.

Preferably, the foot supports are mounted so as to permit rotation about the shaft, to accommodate the changes in the angle of each foot as the leg is bent and straightened. Conveniently the foot supports carry attachments to hold the feet against the supports during exercising. For example, simple straps attached to the supports may be temporarily secured around the feet, for example by a buckle or Velcro® fastener. Stops may be provided to limit the range of movement achieved at the knee and hip. The foot supports may be movable towards and away from each other, to suit different users, and the supports may be held in a desired lateral position by means of slidable collars, one on each side of the support, having removable pins therethrough co-operating with selected ones of a series of spaced holes through the shaft along its length.

Springs may be provided to give a force against which the patient exercises. This will, of course, be important where the patient has only one leg, or is able to exercise only one leg.

The device is simple and relatively inexpensive in construction, permitting use on an individual basis by patients, rather than shared use, accelerating the benefits of exercise in the critical time immediately after surgery and before the patient is able to get out of bed, thereby minimising the risk of deep venous thrombosis. The device is easy to use, and may be set up to suit a range of patients of different sizes and strengths. It also enables the patient to control the rate of usage to what the individual can manage, while at the same time permitting the work required by the patient to be gradually increased as strength builds up.

Brief Description of the Drawings

In the drawings, which illustrate exemplary embodiments of the device of the invention:

Figure 1 is a perspective view of one embodiment of the device attached to the end of a hospital bed, only part of which is shown for the sake of clarity;

Figure 2 is a side elevation of an alternative embodiment, but with the foot supports omitted;

Figure 3 is a front view of one of the foot supports;

Figure 4 is a rear view of the foot support shown in Figure 3;

Figure 5 is a section on line A-A in Figure 4;

Figure 6 is a diagrammatic top plan view of a third embodiment of the invention;

Figure 7 is a sectional view through a portion of a fourth embodiment of the invention; and

Figure 8 is a diagrammatic perspective view of the main components (left side foot support omitted) of the embodiment of Figure 7.

Detailed Description of the Illustrated Embodiments

Referring first to Figure 1, the device comprises a main support member 1 which is suitably in the form of a flat board having at its lower part a screw-operated clamp 2 for securing the device to a bed end 3. It will be appreciated that different types of bed have different shaped ends, and different clamping arrangements will be needed for different beds.

A spaced parallel pair of plates 4 extend normally from the support member 1. Rotatably mounted between the plates 4 is a cylinder 5, the mounting shaft for the cylinder between the plates 4 (not shown) having a screw thread at its upper end on which a control knob 6 is threaded. Rotation of the control knob 6 increases or decreases the clamping force exerted by the plates 4 on the cylinder 5, thereby increasing or decreasing the resistance to rotation of the cylinder.

A horizontal shaft 7 extends through the cylinder 5 and is fixed therein. The shaft 7 carries a pair of foot supports 8, one on each side of the cylinder 5. Each foot support 8 consists of a generally foot-shaped plate 9 having straps or other means (not shown) for supporting the user's feet on the supports in use. On the rear face of each plate 9 is mounted a pair of brackets 10 having a hub 11 rotatably mounted between them so as to be able to rotate about an axis normal to the shaft 7. The hub 11 has a bore therethrough into which the shaft 7 is received so that the hub, and with it the plate 9, can rotate freely about the shaft. The hub 11 is secured against sliding along the shaft 7 by means of a pair of collars 12, only one of which from each pair is visible in the Figure. The collars 12 are also slidable along the shaft 7, but are held at a chosen position by means of a pin 13, which passes through a hole in the collar and through a corresponding one of a series of holes 14 through the shaft, spaced therealong.

Stops 15 mounted between the plates 4 on each side of the device serve to limit the rotation of the cylinder, and hence the foot supports, to a comfortable and effective range. The stops 15 may be removable to permit them to be replaced by smaller or larger stops, or dispensed with entirely, to vary the amount of movement allowed.

In use, the device is adjusted vertically by the clamp 2 to a comfortable position for the patient lying in the bed. The patient's feet are then supported on the foot supports 8 by the removable supporting straps, and the spacing between the foot supports is adjusted to suit the patient's size and shape. The patient then simply bends and straightens each leg in turn, as far as can be managed without excessive pain (it will be appreciated that such exercise, following on closely after surgery, will inevitably involve some discomfort). This is repeated as often as the patient can manage, and whenever the patient is motivated to try the exercise, without the need for continual supervision by a therapist. As the patient is able to achieve a greater degree of movement, the screw knob 6 can be turned a small degree to increase the resistance to rotation of the shaft 7 about the cylinder axis, thereby increasing the work done by the patient and hence the beneficial effects of the exercise. By gradually increasing the resistance in small increments, the patient is not subjected to sudden increases in load, but is encouraged gradually to increase the exercise benefits achieved.

Referring now to Figures 2 to 5, an alternative embodiment of the device of the invention comprises a main support frame 20 having an upright portion 20a and a generally horizontal plate 20b extending from the upper end thereof. A second, matching horizontal plate 21 is attached to the upright portion 20a to extend parallel to the plate 20b, and a flat plastics cylinder 22 is rotatably mounted between the plates. A clamping screw passes through the plate 20b and the cylinder 22 and engages a threaded bore in the lower plate 21. A knob 23 on the screw permits it to be rotated and exerts a clamping force on the upper plate 20b to clamp the cylinder 22 between the plates. By rotating the knob 23, the resistance to rotation of the cylinder can be increased or decreased to suit the user. A horizontal shaft 24 is mounted in the cylinder and extends transversely of the device, and this shaft carries the foot supports as described hereinafter with reference to Figures 3, 4 and 5.

The upright portion 20a also carries a hook member 25 whose position can be adjusted vertically by means of a clamping screw 26, and a stabilising plate 27 which extends generally horizontally beneath the plates 20b and 21 at a distance which can be adjusted. The hook member serves to engage a horizontal part 28 of the bed end, while the stabilising plate 27 rests on the upper surface of the bed mattress 29.

Rotation of the cylinder 22 can be limited in use by means of a control screw 30 which is passed through one of four holes in the upper plate 20a, though a corresponding slot or hole in the cylinder 22, and into a threaded hole in the lower plate 21. The cylinder has three curved slots of varying length to permit different angular limits of rotation, and one hole to permit the cylinder to be fixed against rotation so that the device can be used for exercises which involve only flexing and straightening of the ankle.

Figure 3 shows the side of the foot support 31 presented to the user. It comprises a flat surface 32 against which the user presses a foot, and a curved heel support 33 projecting forward therefrom. Two slots 32a at either side of the surface 32 serve for attachment of straps to help hold the foot against the support in use. The straps can be fastened together by any suitable means, for example Velcro® fastening materials.

The reverse side of the foot support can be seen from Figure 4. A vertical groove 34 extends for the greater part of the height of the support and is formed with an undercut 35 on each side, as may be seen from Figure 5. A mounting body 36 has a back-plate 37 with a slide 38 which engages in the groove 34 in the support. A series of locking holes 39 are formed in the base of the groove 34, engageable by a spring-loaded pin 40 mounted on and extending through the back-plate 37, so that the vertical position of the surface 32 relative to the shaft 24 can be pre-set at any one of a number of different settings. An upper mount 41 and a lower mount 42 extend normally to the back-plate 37, and carry between them a part-cylindrical body 43 rotatable about a pair of pivot pins 44 extending into the mounts 41 and 42. The body 43 has a bore therethrough through which the shaft 24 passes. The shaft 24 has a longitudinal groove therealong (not shown), from which short branches 45 extend part-circumferentially at intervals along its length. A grub screw 46 passes through the body 43 and into the groove or one of its branches to position the foot support at a predetermined position along the shaft. By rotating the foot support rearwardly, the grub screw 46 enters the

groove and allows the foot support to be slid along the shaft. When it reaches the desired lateral location, the support is returned to its upright position, the grub screw entering the respective branch 45 and holding the support at this location. The grub screw also impinges against the upper end of the branch 45, holding the foot support upright and preventing it from rotating rearwardly too far. The length of the branch is preferably such as to permit rotation of the foot support rearwardly through an angle of up to about 15°, i.e. with the user's toes pointing towards the user, while rotation in the other direction can, of course, be as far forward as is permitted by flexure of the user's ankle. Thus, with the cylinder 22 locked against rotation, a beneficial form of exercise may be performed by rotating the feet on the foot supports forward and rearward so as to cause repeated flexion of the calf muscles, thereby giving rise to the muscle pump action as hereinbefore described.

The body 43 has two angled faces 47 which engage the back-plate 37 at the extremes of rotation of the foot support relative to the shaft 24, thereby preventing excessive rotation around the pivot pins 44, while allowing enough rotation to allow the foot supports surfaces to remain parallel to each other and generally parallel to the bed end during use of the device. The upper mount 41 also has a bore therethrough through which a locking pin 48 can be pushed to engage a bore in the body 43 to lock it against rotation during certain types of exercise not involving rotation of the cylinder 22, as hereinbefore described.

In the device shown in Figure 6, the rotatable cylinder 60 carrying the horizontal shaft 61 is mounted on an extension 62 to the main support 63 extending away from the user. The main support 63 has a body 64 in which are provided parallel tracks. A pair of foot supports 65 are mounted one on each side of the body 64 by means of rollers which run in the tracks, allowing the foot supports 65 to slide longitudinally towards and away from the user. As with the embodiment described with reference to Figures 2 to 5, the main support carries a plate 66 which rests on the bed mattress, while the support attaches to the bed end (not shown).

Each foot support 65 has a connecting rod 67 pivotally attached thereto and pivotally connected also to a respective coupling block 68, the blocks 68 being slidably and lockably mounted on the shaft 61 on opposite sides of the cylinder 60. Thus, as

each foot support 65 is pushed forward, in turn, by a respective one of the user's feet, the force is transmitted to the other via the connecting rods 67, the shaft 61 and the cylinder 60. The advantage of this arrangement is that the foot supports 65 can be at a comfortable distance apart for an individual user, and the spacing is not altered when the longitudinal movement or stroke of the foot supports needs to be changed. The blocks 68 are simply unlocked, slid outwardly or inwardly to increase or decrease the stroke, and then locked again. Locking may be achieved, for example, by a locking screw, or by a peg engageable in one of a series of indents along the length of the shaft.

Referring now to Figures 7 and 8, the device comprises a main support in the form of an enclosed casing 70 having a lower part 71 and an upper lid 72. The casing 70 has mounted within it a pair of endless plastics drive chains 73, of which only one is illustrated in Figure 8 for the sake of clarity. Each drive chain 73 passes around a spaced pair of sprocket wheels 74 and 75 mounted on respective vertical spindles 76 and 77. The two chains 73 are mounted one vertically above the other, with their sprocket wheels sharing the spindles 76 and 77. The casing 70 has a slot along a part of each side thereof in which slides a plastics carrier 78 having a main body 78a outside the casing carrying a horizontal axle 79. Within the casing, the carrier has a mounting block 78b from which a guide tongue 78c extends into a guide groove 80 in the lower part 71 of the casing 70. The upper and lower chains 73 are secured to the mounting block 78b by means of pins 81. The carriers 78 are formed as a single plastics body, for example of polypropylene or nylon.

A foot support 82 is mounted on each of the axles 79, the foot supports 82 being generally of the same construction as hereinbefore described with reference to Figures 3 and 4, and being mounted on the axles in the same general manner so as to be rotatable in a vertical plane around the axles, thereby providing for ankle flexion.

It will be seen that the device of this embodiment can provide for exercise involving alternate straightening and bending of the legs in opposition to each other in the same manner as in the preceding embodiments, but with the ability to keep the spacing between the legs constant, as the linkage between the foot supports on opposite sides of the device is linear, rather than one which results in angular movement.

The vertical rotatability of the foot supports about the axles 79 has two functions. Firstly it allows for the variation in the angle of the foot as the leg straightens and bends, and secondly it permits another form of exercise to be carried out, either independently of the straightening and bending exercise or simultaneously therewith, namely ankle flexion, in which the ankle is repeatedly straightened and bent, thereby causing the calf muscles to be exercised. As hereinbefore described, it is thought that such an exercise is important in minimising the risk of thrombosis by causing a "muscle pump" action which improves blood flow.

A clamping nut on one of the sprocket wheels can be rotated to apply a greater or smaller clamping force to vary the resistance to rotation of the wheel and hence the resistance to movement of the foot supports, thereby increasing or decreasing the exercise value of the device, according to an individual user's need at any given time.

The device of the fourth embodiment, being largely contained within an enclosed casing, is easier to keep clean and sterile, as well as being easier to transport from one bed to another and to prepare for use at each bed.

CLAIMS

1. A rehabilitative exercise device comprising a support means mounting two foot supports connected together so as to be alternately reciprocable relative to the support means in a single, generally horizontal, plane, each foot support being freely and independently pivotable about a respective horizontal axis extending generally transversely of the direction of reciprocation.

2. An exercise device according to Claim 1, wherein the support means includes an endless drive member passing around a spaced pair of horizontal wheels, the foot supports being carried on respective horizontal bars attached to opposed runs of the endless drive member.

3. An exercise device according to Claim 2, wherein the support means includes a second endless drive member passing around a second pair of horizontal wheels spaced vertically from and coaxial with the first pair, the second drive member also being attached to the horizontal bars.

4. An exercise device according to Claim 2 or 3, wherein the or each endless drive member is a chain and the wheels are sprocket wheels.

5. An exercise device according to Claim 4, wherein the or each chain is a plastics chain.

6. An exercise device according to Claim 4 or 5, wherein the sprocket wheels are formed of plastics material.

7. An exercise device according to Claim 2 or 3, wherein the or each endless drive member is a toothed belt.

8. An exercise device according to Claim 7, wherein the horizontal wheels are provided with teeth which engage the teeth of the belt or the respective belt.

9. An exercise device according to any preceding claim, comprising means for varying the resistance to reciprocating movement of the foot supports.

10. An exercise device according to Claim 1, wherein the support means mounts a generally horizontal member pivoted generally centrally thereof about a substantially vertical axis, and the foot supports are coupled to the shaft, one each side of the axis, so as to be alternately reciprocable in a generally horizontal plane, each foot support being pivotable about a substantially vertical axis.

the axis, so as to be alternately reciprocable in a generally horizontal plane, each foot support being pivotable about a substantially vertical axis.

11. An exercise device according to Claim 10, wherein the foot supports are mounted directly on the horizontal member.

12. An exercise device according to Claim 10 or 11, comprising means to control the resistance to rotation of the horizontal member about the vertical axis.

13. An exercise device according to Claim 12, wherein the control means comprise a variable friction arrangement.

14. An exercise device according to any of Claims 10 to 13, wherein the foot supports are connected to the horizontal member via connecting rods.

15. An exercise device according to any preceding claim, wherein the foot supports carry attachments to hold the feet against the supports during exercising.

16. An exercise device according to any preceding claim, comprising stops to limit the range of movement achieved at the knee and hip.

17. An exercise device according to any preceding claim, comprising mounting means for attaching the support means to the end of a bed.

18. An exercise device according to Claim 17, wherein the mounting means comprises a removable clamp.

19. An exercise device according to any preceding claim, wherein the foot supports are mounted so as to be constrained from rotation rearwardly by greater than 15° from the vertical.

20. A rehabilitative exercise device, substantially as described with reference to, or as shown in, Figure 1, Figures 2 to 5, Figure 6, or Figures 7 and 8 of the drawings.

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Application No:	GB 0005777.8	**Examiner:**	John Hewet
Claims searched:	1 to 19	**Date of search:**	12 July 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): A6M (MAE, MAX)

Int Cl (Ed.7): A63B 23/04, 23/08

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2233570 A	(HANOVER) see especially arrow A, figure 1	1, 10 to 14 and 16
X	EP 0761259 A1	(OLARU) see especially slides 5 and pivot 29 of figure 2	1 and 15 to 19
X	US 5792028	(JARVIE) see especially pedals 134, figure 1	1, 15 and 16
A	US 5514053	(HAWKINS) see especially figure 1C	
X	US 5044355	(REOPELLE) see especially pivots 13, figure 4	1, 15 and 16
X	US 3941377	(LIE) see especially foot rests 39, 40 connected to belt 11	1, 2, 15 and 16

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.